Research Report 1309

EFFECTS OF TRAINING SCHEDULE AND EQUIPMENT VARIETY ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

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To help guide training course revision efforts of the United States Army Ordnance Center and School (USAOCS), the present experiment examined the effects of training schedule and equipment variety on maintenance task retention and transfer. The experiment contained a training and a testing segment. During training, four groups of 15 student Fuel and Electrical Repairers, 63G Military Occupational Specialty (MOS), performed the task of testing charging system electrical output. Each group performed three task repetitions under one of four training conditions formed by the factorial combination of two training

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schedules (massed, spaced) and two levels of equipment variety (present, absent). Massed scheduling allowed no rest pauses between successive task repetitions; spaced scheduling allowed one-day rest pauses between repetitions. When equipment variety was present, students performed one repetition on each of three charging systems. When equipment variety was absent, all three repetitions were performed on the same charging system.

Testing included two retention tests and one transfer test. The first retention test occurred immediately after training, while the second occurred an average of 14 days later. The transfer test was given immediately after the delayed retention test.

Retention test performance was faster and more accurate after spaced than after massed training. Only the massed schedule groups showed significant ($p < .05$) retention losses between immediate and delayed testing. Spaced scheduling also promoted superior transfer test performance. Equipment variety had no affect on retention, but enhanced transfer test performance when training was spaced. Thus, the best transfer resulted when training task repetitions were spaced and performed on different equipment.

It was concluded that: (a) spacing of task repetitions during training is an effective way to improve both retention and transfer of maintenance skill; and that (b) added transfer improvements can be obtained by coupling spaced task repetitions with increased equipment variety during training.

This report is intended for military training personnel.

Research Report 1309

EFFECTS OF TRAINING SCHEDULE AND EQUIPMENT VARIETY ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

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FOREWORD

The Training Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) maintains a program of research in support of the systems engineering approach to training. A major focus of this research is the development of fundamental data and technology necessary to field integrated systems for improving individual job performance.

This report is one of a series on specific topics in the area of skill acquisition, retention and transfer. It examines the effects of training schedule and equipment variety on the retention and transfer of maintenance skill. The work was accomplished by ARI personnel under Army Project 2Q162722A791 FY80, "Manpower, Personnel and Training" with the combined support of BG D. W. Stallings, Commanding General and Commandant, and Mr. W. C. Ball, Director, Training Development Directorate, at the US Army Ordnance Center and School, Aberdeen Proving Ground, Maryland.

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EFFECTS OF TRAINING SCHEDULE AND EQUIPMENT VARIETY ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

BRIEF

Requirement:

To help guide maintenance training course revision efforts of the United States Army Ordnance Center and School (USAOCS) by determining: (a) how training task repetitions should be scheduled for maximum maintenance effectiveness; and (b) whether an increase in equipment variety during training enhances maintenance performance.

Procedure:

The experiment contained a training and a testing segment. During training, four groups of 15 student Fuel and Electrical Repairers, 63G Military Occupational Specialty (MOS), performed the experimental task of testing charging system electrical output using the 500A Sun Test Stand. Each group received test stand familiarization instruction followed by three training task repetitions under one of four conditions formed by the factorial combination of two repetition schedules (massed, spaced) and two levels of equipment variety (present, absent). Massed scheduling involved three successive task repetitions without intervening rest pauses. Spaced scheduling involved three task repetitions separated by one-day rest pauses during which additional training was given on other unrelated maintenance tasks. When equipment variety was present, students performed one task repetition on each of three separate charging systems. When equipment variety was absent, all three repetitions were performed on the same charging system. Testing included two retention tests and one transfer test. The first retention test occurred immediately after training, while the second occurred an average of 14 days later. The transfer test was given immediately after the delayed retention test. Retention was tested on a charging system used during training, whereas transfer was tested using an unfamiliar charging system. Performance aids were used during both the training and testing segment of the experiment.

Findings:

Retention performance was faster and more accurate after a spaced than after a massed training task repetition schedule. During the interval between immediate and delayed testing, task performance times increased an average of 51% for the massed groups versus 6% for the spaced groups, while the average increase in errors for massed groups was 107% compared to only 15% for the spaced groups. Only the performance decrements for the massed groups were statistically significant ($p < .05$). The presence of equipment variety during training did not affect retention.

Transfer performance was significantly faster and more accurate after spaced than after massed training. Equipment variety also enhanced

transfer, but only when introduced during spaced training. Thus, the best transfer performance was found when training task repetitions were spaced and performed on different equipment.

Utilization of Findings:

Spacing of task repetitions during training can be viewed as an effective way to enhance both retention and transfer of maintenance skill. Additional transfer improvements can be obtained by coupling spacing with an increased use of equipment variety during training.

Future research is needed to determine: (a) the most effective spacing intervals to use between training task repetitions for improving maintenance performance; (b) whether differential effects of spaced and massed training schedules occur for different categories of maintenance tasks; and (c) the quantity and type of equipment variation needed during training to promote the most effective transfer of maintenance skill.

EFFECTS OF TRAINING SCHEDULE AND EQUIPMENT VARIETY ON RETENTION AND TRANSFER OF MAINTENANCE SKILL

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INTRODUCTION

Two primary goals of the Army are enhanced combat proficiency and increased combat readiness among its fighting force (Guthrie, 1979). The current trend within the Army toward increased mechanization (Meyer, 1980) has made achievement of these goals more and more dependent on equipment operability and on the quality of equipment maintenance performed by Army personnel.

It is generally accepted that maintenance throughout the Army must be improved (Gregg, 1979; Johansen, 1979). To accomplish this, the Army has initiated the Maintenance Management Improvement Program. This program has as its primary goal the correction of serious maintenance deficiencies that exist currently within the Army. One suggested way to achieve this goal within the program is to strengthen maintenance training in service school curriculums (Johansen, 1979). To this end, the United States Army Ordnance Center and School (USAOCS) is currently revising the Advanced Individual Training (AIT) program of instruction (POI) for each Military Occupational Specialty (MOS) contained within the Mechanical Maintenance Career Management Field (CMF 63). The objective of this revision process is to increase maintenance training effectiveness, defined as both improved retention of AIT-acquired skill and as enhanced transfer of this skill to post-AIT job performance.

To help guide course revision efforts, the USAOCS requested specific information on how the variables of task repetition, training schedule, and equipment variety influence maintenance task performance. Interest in these variables stems from their potential influence on maintenance training effectiveness and on training time and resource constraints that drive USAOCS course development and revision efforts.

The specific questions of interest related to these three variables were:

(a) Does increased task repetition during training improve retention and transfer of maintenance skill;

(b) How should task repetitions be scheduled during training for maximum effectiveness;

(c) Does increased equipment variety during training task repetitions improve overall maintenance proficiency.

Two experiments were designed to answer these questions. The first experiment (Hagman, in press) addressed the initial question regarding training task repetition effects. Separate groups of 63G MOS (Fuel and Electrical Repairers) students were trained on the task of testing charging system electrical output. This task was repeated from one to four times during training with one group assigned to each level of repetition. Both retention and transfer scores were recorded. Retention was tested both immediately and 14 days after training; transfer was tested immediately after the delayed retention test. It was found that: (a) immediate and delayed retention improved with increased task repetition; (b) maximum task speed and accuracy occurred at the third task repetition with no further improvement resulting from execution of a fourth; (c) transfer was not influenced by increased task repetition.

With the effects of task repetition identified in this initial experiment, the second, and present, experiment was directed toward answering the remaining two questions of concern to the USAOCS. These questions involved the examination of training schedule and equipment variety effects on the retention and transfer of maintenance skill.

Training Schedule

The scheduling question translated into a comparison of spaced versus massed practice effects. The primary difference between these two schedules is that spaced practice allows rest pauses between successive task repetitions, whereas massed practice does not.

Experiments comparing spaced and massed practice are pervasive throughout the literature. Although much work has been done in this area, no definitive conclusions can be made regarding the relative merits of each schedule because of differential findings reported across experiments. For example, D'Agostino & DeRemer (1973) and Proctor (1980) report that spaced practice is more effective than massed practice, whereas Schmidt (1975) and Underwood (1964) report just the opposite. To add more confusion, other investigators (e.g., Bugelski, 1962; Schendel & Hagman, in press) report that massed and spaced practice are equally effective. Thus, one is compelled to conclude that the relative effectiveness of spaced and massed practice is specific to task and procedural differences existing across experiments. This situation has prevented the USAOCS from applying the results of laboratory training experiments to operational training problems.

Application of laboratory results also has been discouraged by the many procedural differences that have existed between laboratory and operational training programs. One of the most obvious, and perhaps most important, of these procedural differences has involved spaced practice. Spaced practice in the laboratory typically includes unfilled rest pauses between successive task repetitions (e.g., Catalano, 1978). Operational training programs, on the other hand, fill rest pauses with additional training on other tasks because of time constraints on total course length. Thus, comparisons of spaced and massed practice in operational settings will depend much on the influence of other task training during spaced practice rest pauses.

The effect of other task training on acquisition, retention and transfer of the original task has been a topic of theoretical debate. Welford (1976), for example, suggests that training on other tasks during rest pauses should interfere with rehearsal of the original task and thereby, decrease acquisition and retention of the original task. In contrast, Battig (1972, 1978) contends that the interference generated by other task training forces a person to encode the original task in a more elaborate and distinctive fashion, and thus, should facilitate retention and transfer of original task learning.

Recent data (e.g., Bregman, 1967; Gotz & Jacoby, 1974; Hiew, 1977; Shea & Morgan, 1979) support Welford's position for acquisition and Battig's position for retention and transfer. Shea & Morgan (1979), for example, have found that other task training depressed acquisition of an original serial movement task but improved its later retention and transfer. Thus, a massed practice schedule, where other tasks are not trained between original task repetitions, should promote superior acquisition. In contrast, a spaced practice schedule, where other tasks are trained, should produce superior retention and transfer of the original task. The present experiment examined whether these expected effects occur for acquisition, retention and transfer of maintenance skill.

Equipment Variety

Equipment variety was examined primarily to determine its effect on transfer of training. In the initial experiment of this series (Hagman, in press), 63G students performed the task of testing electrical output of a 100A alternator from one to four times during initial training, and then performed the same task on a 60A generator. Transfer of initial training to the 60A generator failed to increase with the number of prior task repetitions.

One suggested reason for this lack of improved transfer, was the absence of task variety during training. Previous researchers have found variety of training to be the key to improved motor (e.g., Duncan, 1958; Husak & Reeve, 1979; Wrisberg & Ragsdale, 1979) and verbal task transfer (e.g., Baker, Santa & Gentry, 1977; Ellis, Grah & Spiering, 1975), especially under conditions of training task repetition (e.g., Bevan, Dukes & Avant, 1966). In addition, variety has been invoked recently in theoretical accounts as being essential for transfer development (e.g., Schmidt, 1975b). The present experiment introduced variety during training by increasing the number of charging systems tested, thereby allowing the examination of equipment variety effects on transfer of maintenance skill.

METHOD

Subjects

Sixty students from the AIT course for Fuel and Electrical Repairers, 63G MOS, participated in the experiment. Each was randomly selected

from the total number of USAOCS students trained between 1 February and 1 October 1980.

Design and Procedure

The experiment contained a training and a testing segment, as shown in Figure 1. During training, four groups of 15 students performed the experimental task of testing charging system electrical output using the 500A Sun Test Stand. Each group performed three task repetitions under one of four training conditions[1]. The four training conditions were formed by the factorial combination of two training schedules (massed, spaced) and two levels of equipment variety (present, absent). Massed scheduling involved three successive task repetitions without training on other tasks between repetitions. Spaced scheduling involved three task repetitions separated by one-day rest pauses. Training on brakes and personnel heaters was given during these rest pauses[2]. When equipment variety was present, students performed one task repetition on each of three similar charging systems, i.e., 25A generator, 300A generator, 100A alternator. When variety was absent, all three task repetitions were performed on the same charging system, i.e., 100A alternator. The last training task repetition for all groups was on the 100A alternator. This was done to ensure identical retention intervals between the end of training and retention testing. Training for all groups was performance-oriented, individualized-mode, instructor-assisted instruction conforming to current USAOCS training procedures.

Prior to the first training trial, all students received general familiarization information on test stand operation. This involved explanation of; (1) the purpose and use of the test stand, (2) what each meter measures and how to interpret meter readings in relation to the charging system being tested, (3) the purpose and use of switches and controls critical to testing of alternators and generators, (4) emergency shutdown procedures, and (5) "base settings" of switches and controls and their importance in preventing damage to the test stand and the charging system being tested. Familiarization also included a practical demonstration of a charging system being tested. Training began immediately after familiarization instruction. All students used material from USAOCS Special Text (ST) 9-4910-485-12 as a performance aid during training.

Testing occurred three times after training, as shown in Figure 1. The first test was given immediately after training. Performance on this test indicated the degree to which students had learned the task. The second test was given an average of 14 days later. The purpose of

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[1] Three repetitions were selected for training on the basis of results obtained earlier (Hagman, in press).

[2] Although this design allows spaced practice to differ from massed practice in terms of both rest pauses and the training of other tasks during rest pauses, it was selected because it directly compared the relative merits of the only massed and spaced schedules judged feasible for implementation within an operational training program.

TREATMENT		TRAINING	TESTING			
EQUIPMENT VARIETY	SCHEDULE	GROUP	IMMEDIATE		DELAYED	TRANSFER
ABSENT	MASSED	AAA	A		A	X
ABSENT	SPACED	A,A,A	A	14 DAY INTERVAL	A	X
PRESENT	MASSED	BCA	A		A	X
PRESENT	SPACED	B,C,A	A		A	X

A = 100A ALTERNATOR; B = 25A GENERATOR; C = 300A GENERATOR; X = 60A GENERATOR

Figure 1. Experimental design

this second test was to examine long-term task retention over a period of no practice. Students used the same performance aid during immediate and delayed testing as during training. The third test was given immediately after the delayed retention test and was designed to examine transfer. Transfer was examined using an unfamiliar charging system, i.e., 60A generator, whereas retention was examined using a charging system present during training, i.e., 100A alternator. Consistent with earlier procedure, a performance aid was used during transfer testing.

A 2 x 2 x 2 mixed factorial design was used to examine retention test performance with the between-subjects variables being Equipment Variety (present, absent) and Training Schedule (massed, spaced) and the within-subject variable being Time of Testing (immediate, delayed). Transfer performance was examined using a 2 x 2 factorial design with Equipment Variety (present, absent) and Training Schedule (massed, spaced) both as between-subject variables.

Task

The training, retention and transfer tasks contained five major segments; (1) setting of test stand switches and controls to base positions, (2) attachment of charging system cables to test stand, (3) setting of test stand switches to positions appropriate for alternator or generator testing, (4) performance of electrical output testing procedures, and (5) performance of test stand shutdown procedures. The specific steps associated with these segments are listed in USAOCS Special Text (ST) 9-4910-485-12. Relevant portions of this ST were adopted for use as performance aids (See Appendix).

Equipment

Two models (AGT-9 and AGT-9A) of the Sun Test Stand were used. Both were identical except for minor differences in ac testing range. A detailed description of the Sun Test Stand is in Technical Manual (TM) 9-4910-485-12.

The charging systems were all pulley-driven units. The 100A alternator and the 60A generator were manufactured by Leece-Neville, whereas the 25A and 300A generators were manufactured by Prestolite and Teledyne, respectively. Each charging system was mounted on a test stand prior to the start of the experiment.

RESULTS AND DISCUSSION

Retention and transfer test performance was scored for speed and accuracy. Each performance measure was analyzed separately.

Retention

Speed. Retention test performance time varied as a function of training schedule and time of test. As shown in Figure 2, substantial forgetting occurred under massed training, whereas minimal forgetting

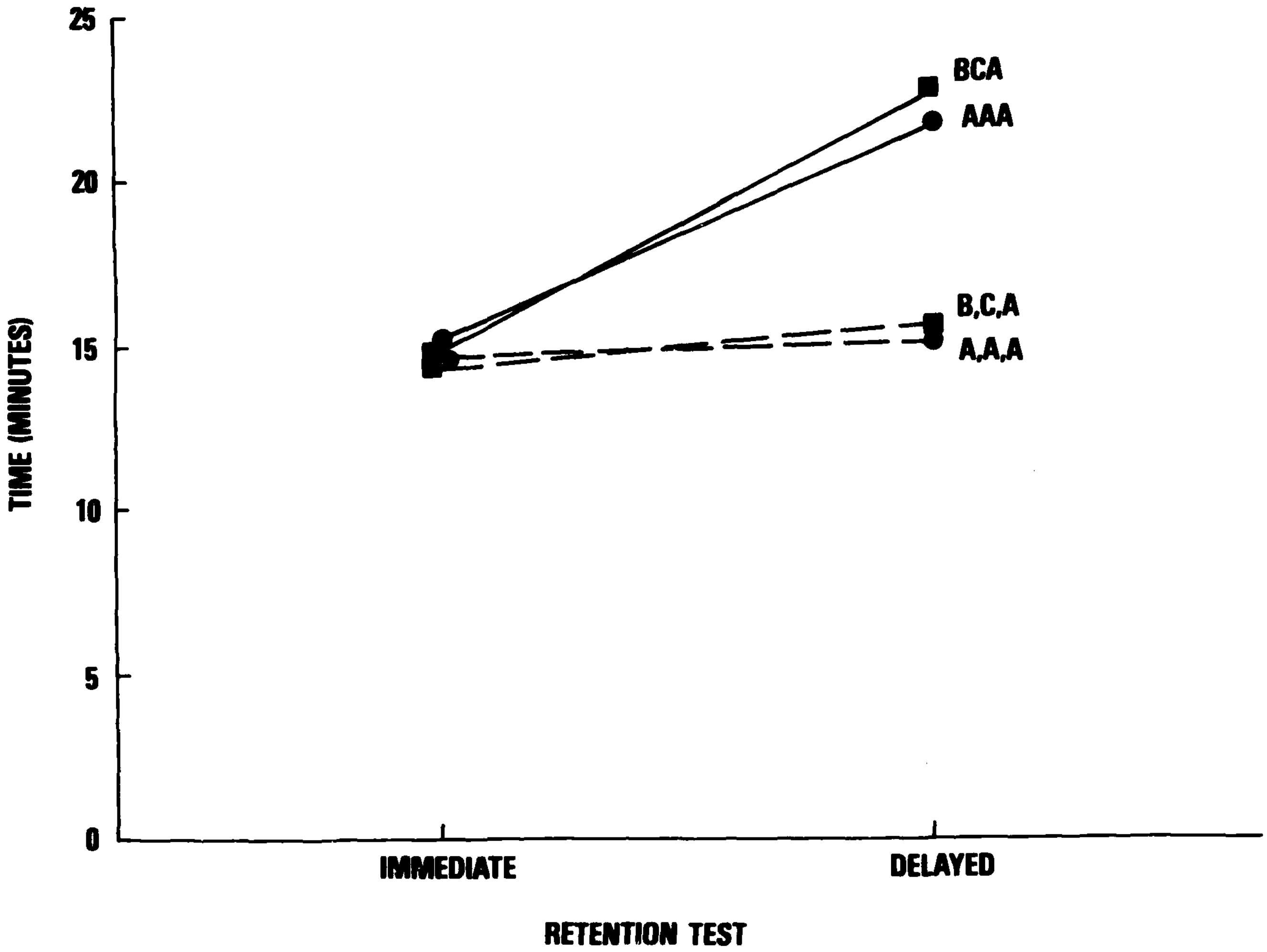

Figure 2. Average immediate and delayed retention test performance time obtained for spaced and massed training schedule groups with and without equipment variety.

occurred under spaced training. Test performance time increased 46% and 57% for Groups AAA and BCA from immediate to delayed testing; Groups A,A,A and B,C,A displayed only a 1% and 10% increase, respectively. Visual inspection of Figure 2 also revealed that groups did not differ at immediate retention testing and that equipment variation during training had no effect on retention test performance.

To examine the reliability of these observations, a 2 x 2 x 2 mixed factorial analysis of variance (ANOVA) was performed with Training Schedule (massed, spaced), Equipment Variety (present, absent), and Retention Interval (immediate, delayed) as variables. This ANOVA revealed a significant ($p < .05$) main effect of training schedule, $F(1,56) = 8.25$, and retention interval, $F(1,56) = 18.64$, and a significant training schedule x retention interval interaction, $F(1,56) = 11.76$. The schedule main effect demonstrated the general superiority of spaced training while the interval main effect indicated better overall group performance at immediate than at delayed testing. Separate analyses of simple effects associated with the schedule x retention interval interaction using the least significant difference (LSD) method of individual comparison (Carmer & Swanson, 1973), supported conclusions based on visual inspection of Figure 2. The increase in test performance time between immediate and delayed testing was significant for Groups AAA and BCA, but not for Groups A,A,A and B,C,A. As a result, the test performance times of groups A,A,A and B,C,A were faster than those of groups AAA and BCA at delayed testing. These results show that massed training produced significant forgetting in the form of increased task performance time, whereas spaced training prevented this forgetting. These results support the previous laboratory research findings showing that spaced practice enhances task retention (e.g., Proctor, 1980).

Individual comparisons also revealed the absence of group differences in task performance time at immediate testing. If it is accepted that immediate test performance indicates the degree or level of task acquisition, then the lack of group differences shows that neither schedule nor equipment variations during training influenced acquisition of the experimental task. Failure to find a schedule effect indicates that rest periods that include training on other tasks (i.e., brake and personnel heater repair) between spaced repetitions do not impede acquisition. It is possible, however, that practical "ceiling effects" on immediate test times prevented differences between the massed and spaced groups. Although this argument is plausible, it appears improbable because students should not have reached a performance "ceiling" after only three task repetitions. The lack of an effect of equipment variety on immediate test time demonstrates that equally proficient task acquisition can occur when either identical or similar charging systems are used during training. This result probably occurred because of the high degree of similarity existing among the three charging systems used during training. It is possible that increased equipment variation during training could become detrimental to acquisition as equipment similarity decreases. Further research is needed to determine the validity of this notion.

Accuracy. Group error score differences supported those found for time scores. Consistent with other research using performance aids (e.g., Hagman, in press; Horne, 1972), the average number of errors committed during testing was low (i.e., 1.28). As shown in Figure 3, forgetting occurred under massed but *not* under spaced training. Errors increased 178% for Group AAA and 78% for Group BCA from immediate to delayed testing, whereas the increase for Groups A,A,A and B,C,A was only 18% and 13%, respectively. Inspection of Figure 3 suggests that immediate test accuracy was best when task repetitions were spaced and performed on the same equipment (i.e., Group AAA). Delayed test accuracy was best when task repetitions were spaced (i.e., Groups A,A,A and B,C,A) with little or no effect produced by equipment variation.

The reliability of observed error score differences was examined with a 2 x 2 x 2 mixed factorial ANOVA identical to that performed on time scores. This ANOVA revealed a significant ($p < .05$) main effect of retention interval, $F(1,56) = 10.30$, and retention interval x training schedule interaction, $F(1,56) = 5.13$. The retention interval effect reflected the superiority of immediate over delayed testing. A simple effects analysis of the significant interaction only partially supported the group differences observed in Figure 3. Consistent with earlier observations, the increases in error found for Groups AAA and BCA between immediate and delayed testing were significant. Also, the combined average error of the two spaced groups was lower than that of the two massed group at delayed testing. However, the apparent difference between Group AAA and the other three groups at immediate testing, and the apparent overall difference between Groups AAA and BCA were both unreliable ($p > .05$). The absence of group differences at immediate testing indicates that neither schedule nor equipment variations introduced during training influenced acquisition of the experimental task.

Three explanations will be suggested to account for the beneficial effects of spaced training on retention. The first is based on a theoretical model of memory proposed by Atkinson & Shiffrin (1968). In this model, task repetition is thought to promote transfer of to-be-learned information from short- to long-term memory. It is assumed that when an item is already present in short-term memory after the initial task repetition, additional repetitions of that item during training are not beneficial, and therefore, do not increase the probability of item transfer from short-to long-term memory. Once information has been transferred into long-term memory it becomes relatively resistant to forgetting and can be recalled after prolonged retention intervals of no practice. Spaced repetitions are believed to be more effective than massed repetitions because with rest pauses between repetitions it is less likely that information from the first task repetition will still be in short-term memory at the time of the second task repetition.

The second explanation involves the notion of encoding variability. Encoding variability is said to occur when different aspects or attributes of a training task are encoded (memorized) on successive repetitions. Spacing of repetitions increases the likelihood of a task being encoded differently in memory on each repetition. This improves retention by increasing the number of retrieval cues in long-term memory available at

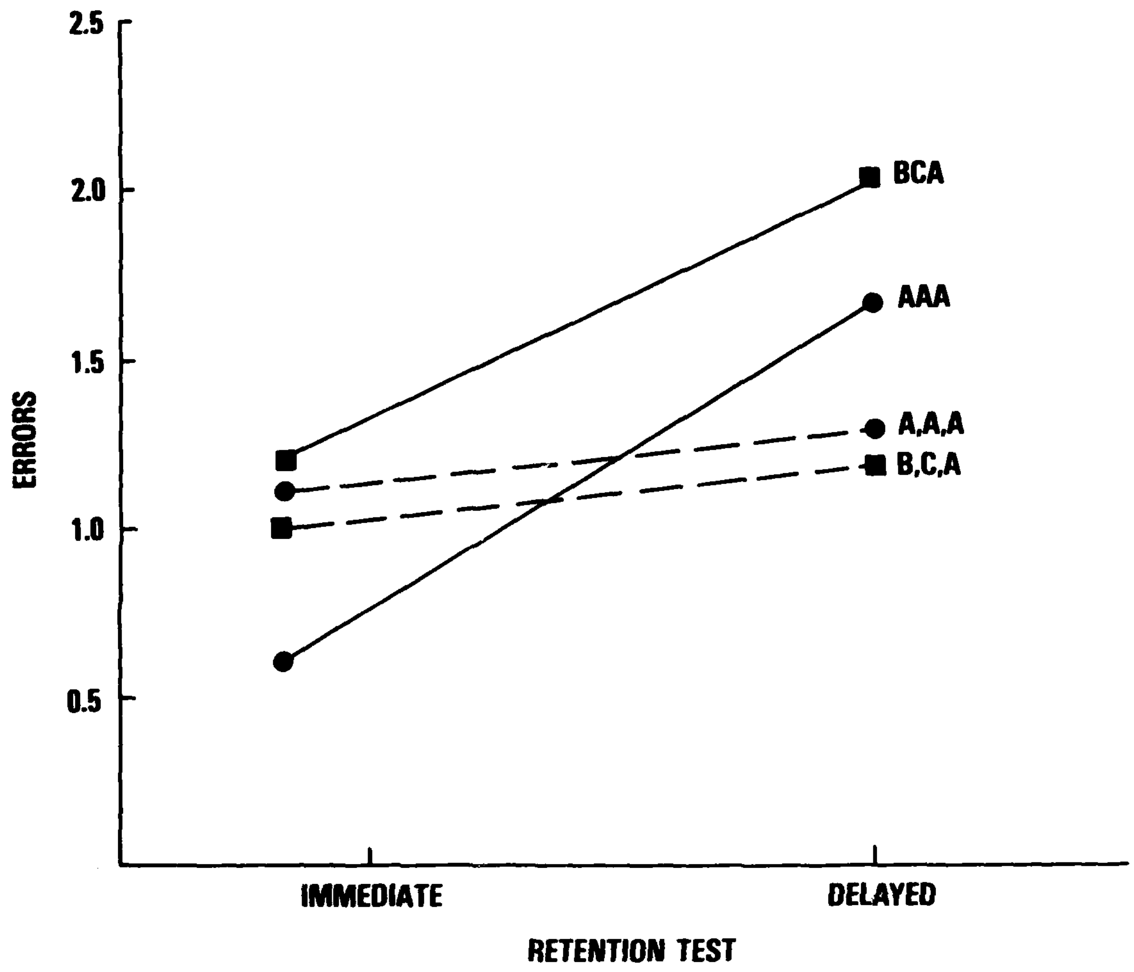

Figure 3. Average number of errors committed at immediate and delayed retention tests by spaced and massed training schedule groups with and without equipment variety.

task recall (Madigan, 1969). Massing of repetitions, in contrast, reduces encoding variability by encouraging a person to encode the task in the same way on each successive repetition. Presumably rest pauses alone are sufficient to encourage encoding variability, however, training of other tasks during rest pauses is also effective. Battig (1978), for example, suggests that interference generated by the training of additional tasks between repetitions of an original task forces the learner to encode the original task in a more elaborate (e.g., variable) and distinctive fashion, thereby, facilitating its retention. Thus, the training of additional tasks during spaced training which typically occurs in operational training programs, benefits retention.

The last explanation of the spacing effect relies on the concept of task organization. Spacing is thought to enhance retention because rest pauses between repetitions form the basis for organizing a task into distinct memory units (e.g., Proctor, 1980). It is assumed that the more separate task units stored in memory, the better a task will be retained. Massed repetitions are not retained as well as spaced repetitions because the former tend to be grouped together as one unit based on the organizational principles of proximity and similarity, whereas the latter do not.

These three explanations do not represent an exhaustive set, but are indicative of the variety of potential explanatory concepts that have been offerred to account for the spacing effect. Each has done a good job of accounting for observed retention advantages found in the laboratory under spaced training and generally appear applicable to the results of the present experiment.

Task segment errors. The retention task contained five segments. Each segment contained a different number of performance steps; Base Switch Settings (28), Cable Connections (2), Switch Settings for the Specific Charging System being tested (3), Testing Procedures (11), and Shutdown Procedures (8). Of particular use to the development or revision of any maintenance training curriculum is information concerning the locus of errors committed during task performance. To this end, the number and percentage of total errors committed by all four groups on each of the five task segments were tallied. Table 1 shows these data for the immediate and delayed retention tests as well as for the two tests combined.

Combined test data revealed that most errors occurred on the Testing Procedures task segment, whereas most of the remaining errors were distributed between the two task segments involving Base Switch Settings and Shutdown Procedures. Students forgot more about Testing Procedures than about any of the other task segments, as indicated by the substantial increase in the number of errors committed between immediate and delayed testing for the Testing Procedures task segment. Presumably, much of this increase was caused by students forgetting how to perform a step rather than what step to perform. This occurred because the Testing Procedures segment placed a greater load on memory than did other segments by requiring task procedures not detailed sufficiently in the performance aid, (i.e., the interpretation of meter values). The procedures for

Table 1

Number and Percentage of Total Errors Committed at Immediate, Delayed and Combined Retention Testing on Each of the Five Test Task Segments

TEST	TASK SEGMENTS									
	BASE SWITCH SETTINGS		CABLE CONNECTIONS		SWITCH POSITIONS FOR SPECIFIC CHARGING SYSTEMS		TESTING PROCEDURES		SHUTDOWN PROCEDURES	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
IMMEDIATE RETENTION	15	25	0	0	3	5	29	48	13	22
DELAYED RETENTION	21	23	1	1	2	2	53	57	16	17
COMBINED	36	24	1	1	5	3	82	53	29	19

other task setments were more detailed in the performance aid, and thus, were not susceptible to forgetting.

Taken together, the task segment error data suggest that: (a) an added emphasis on testing procedures during training would be most beneficial to improved overall task performance; and (b) retention of the Testing Procedures task segment could be improved by incorporating more detailed procedural information in the performance aid. Both of these suggestions are in agreement with those made elsewhere (Hagman, in press).

Transfer

Transfer performance was scored for both speed and accuracy with each measure receiving separate analysis.

Speed. As shown in Figure 4, spacing of repetitions during training produced rapid transfer task performance. Equipment variation during training improved transfer, but only when introduced within a spaced training schedule.

To determine the reliability of these observations, a Training Schedule (massed, spaced) x Equipment Variety (present, absent) factorial ANOVA was performed on task completion time scores. This ANOVA revealed a significant main effect of training schedule, $F(1,56) = 13.26$, to support the observation of superior transfer under spaced training, but no significant training schedule x equipment variety interaction. Although nonsignificant, a priori expectations regarding the beneficial effects of equipment variety on transfer justified further analysis of this interaction. Individual comparisons of simple effects revealed that spacing plus equipment variety produced the best transfer performance. Task performance time for Group B,C,A was significantly faster than the combined average task performance time of the other three groups. Thus, equipment variety did improve transfer, but only when introduced within a spaced training schedule. Variety without spacing was not effective.

Accuracy. Error score results were similar to those found for time scores. As shown in Figure 5, spaced task repetition during training produced the best overall transfer performance. Equipment variety aided transfer, but only when incorporated within a spaced training schedule.

A Training Schedule (massed, spaced) by Equipment Variety (present, absent) factorial ANOVA on error scores revealed only a significant main effect of training schedule, $F(1,56) = 6.81$, supporting the observation that spaced training is more effective than massed training. Although the training schedule x equipment variety interaction was nonsignificant, a priori expectations about the benefits of equipment variety under spaced scheduling justified simple effects comparisons. These comparisons revealed that equipment variety was beneficial to transfer when coupled with a spaced training schedule. The number of errors committed by Group B,C,A was significantly fewer than the combined average number of errors committed by the other three groups.

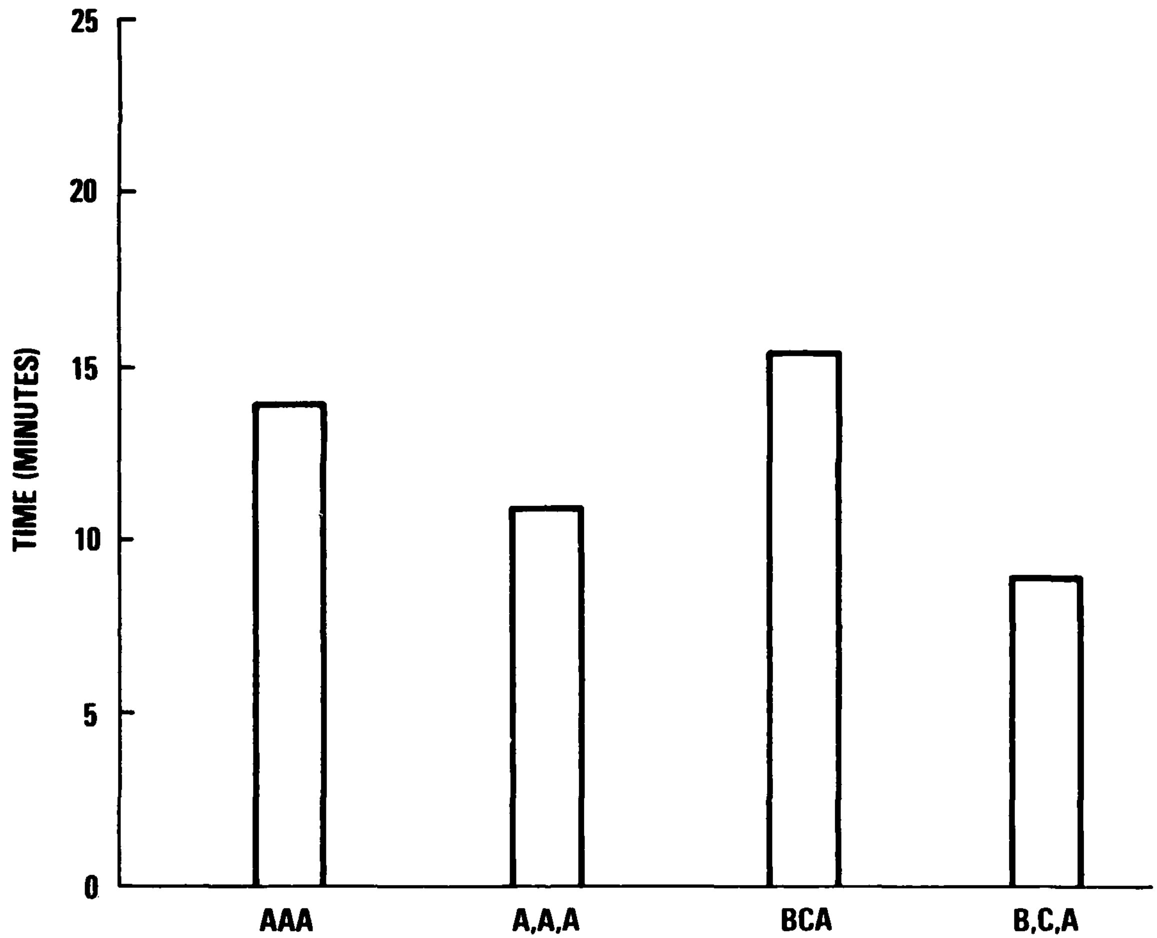

Figure 4. Average transfer test performance time obtained for each training condition.

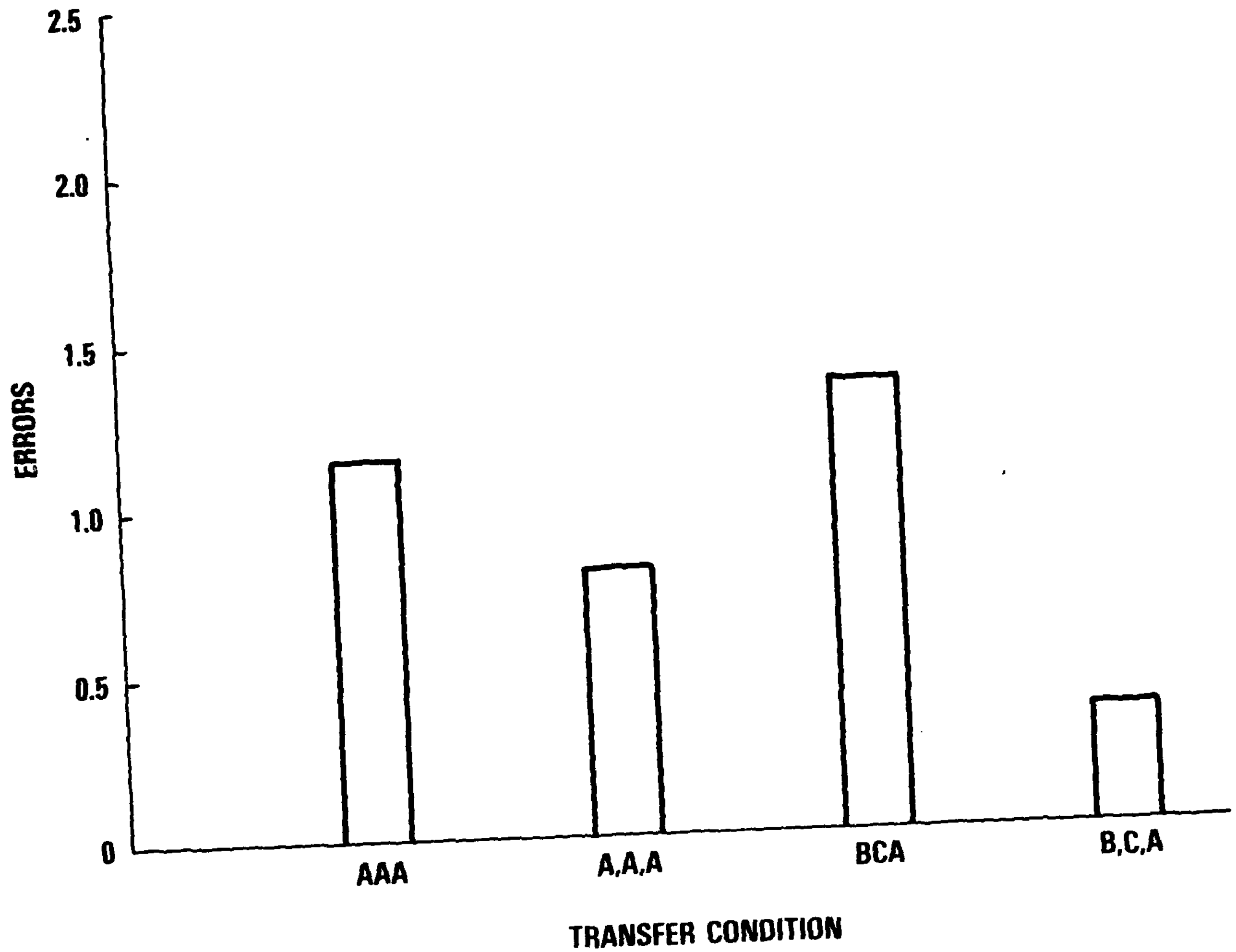

Figure 5. Average number of errors committed at transfer testing for each training condition.

Spaced training probably produced superior transfer because of its beneficial effect on retention. Transfer is contingent upon adequate task retention because of the time interval that occurs between initial training and subsequent performance of the transfer task. In the laboratory, the dependency of transfer on retention is minimized by inserting only brief retention intervals between the end of training and the beginning of the transfer task. When this is done, training schedule variations usually do not influence transfer (e.g., Montgomery, 1953). In an operational context, however, unlike in the laboratory, one may not begin work on a transfer task until weeks after training. Thus, training schedules which enhance retention will also enhance transfer, as found in the present experiment.

Spaced training was also a prerequisite for observing equipment variety effects on transfer. This demonstrates that equipment variation during training is not effective unless retention of initial task training is high, and is consistent with previous research findings showing that increased variety of training in the absence of sufficient task learning does not promote transfer (e.g., Morrisett & Hovland, 1959).

Reasons why equipment variation during training enhanced transfer are not obvious. Examination of the procedural steps listed in each performance aid (see Appendix) suggests that transfer in general was high because of the overall similarity of procedural steps required for the testing of each charging system. Although similarity of steps appears to underlie overall group transfer, it does not explain differential transfer among groups. Differential transfer may have been the result of differential generalized skill development. This generalized skill may have taken at least two forms. First, students may have learned more about general operation of the test stand through the testing of multiple charging systems during training and transferred this knowledge to testing of the unfamiliar charging system used during transfer testing. Second, students may have learned the general transferable principle of looking at and paying attention to every procedural step listed in the performance aids. Presumably, this principle is learned better when different performance aids are consulted than when the same performance aid is consulted on successive training task repetitions. Consistent with this interpretation, Duncan (1958) has suggested that training task variation facilitates the general skill of dealing with or processing new stimuli and that this skill is probably of an observational or perceptual nature. Although both of the above interpretations are plausible explanations of the differential transfer obtained in the present experiment, further research is needed to clarify why varied task training improves the transfer of maintenance skill.

Task segment errors. To determine the locus of errors at transfer testing the number and percentage of errors committed on each of the five transfer task segments were recorded. Table 2 shows these data. The distribution of errors across transfer task segments was similar to that found for retention task segments where steps listed under the Testing Procedures task segment were missed most frequently. This indicates that an emphasis on this task segment should produce substantial transfer benefits as well as the retention benefits mentioned earlier.

Table 2

Number and Percentage of Total Errors Committed at Transfer Testing on each of the Five Test Task Segments

TEST	TASK SEGMENTS: BASE SWITCH SETTINGS		CABLE CONNECTIONS		SWITCH POSITIONS FOR SPECIFIC CHARGING SYSTEMS		TESTING PROCEDURES		SHUTDOWN PROCEDURES	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
TRANSFER	15	28	0	0	1	2	35	64	3	6

SUMMARY AND CONCLUSIONS

The results of the present experiment answer USAOCS questions concerning the effects of training schedule and equipment variety on retention and transfer of maintenance skill. They indicate that spaced scheduling of task repetitions during training is more effective than massed scheduling of task repetitions in sustaining maintenance task retention over a prolonged interval of no practice. Spacing of repetitions is also more effective than massing of repetitions in promoting transfer of training. The optimum time interval to insert between spaced repetitions remains a matter of speculation and will depend on such things the operational constraints of the training situation and the type of task to be trained. An interrepetition interval of one day, for example, may prove most effective for testing charging systems, but not for repairing carburetors. Identification of optimum spacing intervals is important because the spacing effect is nonmonotonic. That is, initially as spacing increases, performance increases; but this spacing advantage reaches a maximum, and for long spacing intervals, performance decreases toward the level observed for massed repetitions (e.g., Peterson, Wampler, Kirkpatrick & Saltzman, 1963).

The results of this experiment also indicate that, when equipment similarity is high, equipment variation during training has no effect on acquisition or retention, but does improve transfer performance when introduced within a spaced training schedule. The benefits of equipment variety, therefore, are contingent upon a training schedule that promotes adequate task retention. The strength of this contingency should vary directly with the length of the retention interval inserted between initial task training and subsequent performance of the transfer task. Additional research is needed to determine the type and quantity of equipment variation necessary to promote the most effective transfer of maintenance skill.

Examination of both retention and transfer task error scores indicates that most errors occur during the Testing Procedure segment of each task. Thus, additional training on this segment should produce the greatest improvement in overall task performance. Under conditions of limited training time availability, this segment should receive initial emphasis.

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PERFORMANCE AID

25 Ampere Generator

SECTION I: BASE SETTINGS

Check (✓)
If Incorrect

Upper Portion of Test Stand

_____ External master power switch. . . . . Off
_____ Main power switch . . . . Off
_____ Motor drive set for CLOCKWISE rotation of generator
_____ DC load ammeter . . . . 500 amperes
_____ DC field ammeter. . . . . 30 amperes
_____ Milivolt meter. . . . . 9 volts and off
_____ DC voltmeter. . . . . 50 volts and RECT/GEN
_____ Tachometer. . . . . Direct drive
_____ AC ammeter. . . . . 500 amperes and phase A
_____ AC voltmeter. . . . . 50 volts and off
_____ 400 ampere control box. Voltage adjust fully counterclockwise
_____ Equalizer coil test . . . . Off
_____ Ignition switch . . . . Off

Lower Portion of Test Stand

_____ Power supply switch . . . . Off and rheostat fully counterclockwise
_____ Battery charger switch. Off and rheostat fully counterclockwise
_____ External field. . . . . Off
_____ Field common. . . . . Negative (-)
_____ Field circuit switch. . . . . Regulator
_____ Relay lamp. . . . . Off
_____ Regulator load resistor selector. . . . . Off
_____ Current polarity. . . . . Negative (-)
_____ Battery selector. . . . . Off
_____ Starter test switch . . . . Off and stator voltage adjusted counterclockwise
_____ All load switches . . . . Off
_____ Field current rheostat. Fully counterclockwise
_____ Variable load . . . . Fully counterclockwise

Bus Bars

_____ B+ to G+
_____ B- to G-

SECTION II: CABLE CONNECTIONS

_____Special purpose cable (No C548-4105) Large lead to G+ of generator section of test stand.

_____Special purpose cable (No C548-4105) small lead to F of generator section of test stand.

_____Cable No C548-4100-14 from generator housing to G- of generator section of test stand.

SECTION III: SPECIFIC SWITCH POSITIONS

_____DC load ammeter to 50A

_____DC field ammeter to 5A

_____Field circuit switch to MANUAL

SECTION IV: TESTING PROCEDURE

_____Turn main power switch ON

_____Depress START button and hold down for 3 to 5 seconds

_____Adjust vari-drive until you read 2000 RPM

_____Turn 25-amp load switch ON

_____Turn master load switch ON

_____Turn field current control clockwise until you read 28-30V on the DC voltmeter and 25A on the DC load ammeter

_____DC field ammeter should read less than 1A

SECTION V: SHUTDOWN PROCEDURE

_____Turn field rheostat fully counterclockwise

_____Reduce speed to 1000 RPM

_____Press STOP button

_____Shut OFF main power

_____Return all switches to base settings

PERFORMANCE AID

100 AMP ALTERNATOR

SECTION I: BASE SETTINGS

Check (✓)
If Incorrect

Upper Portion of Test Stand

______	External master power switch	Off
______	Main power switch	Off
______	Motor drive set for CLOCKWISE rotation of generator	
______	DC load ammeter	500 amperes
______	DC field ammeter	30 amperes
______	Milivolt meter	9 volts and off
______	DC voltmeter	50 volts and RECT/GEN
______	Tachometer	Direct drive
______	AC ammeter	500 amperes and phase A
______	AC voltmeter	50 volts and off
______	400 ampere control box	Voltage adjust fully counter-clockwise
______	Equalizer coil test	Off
______	Ignition switch	Off

Lower Portion of Test Stand

______	Power supply switch	Off and rheostat fully counter-clockwise
______	Battery charger switch	Off and rheostat fully counter-clockwise
______	External field	Off
______	Field common	Negative (-)
______	Field circuit switch	Regulator
______	Relay lamp	Off
______	Regulator load resistor selector	Off
______	Current polarity	Negative (-)
______	Battery selector	Off
______	Starter test switch	Off and stator voltage adjusted counter-clockwise
______	All load switches	Off
______	Field current rheostat	Fully counterclockwise
______	Variable load	Fully counterclockwise

Bus Bars

______ B+ to G+
______ B- to G-

SECTION II: CABLE CONNECTIONS

____ Cable No C548-4102 from alternator connector receptacle to alternator section of test stand

____ Test lead No C548-4100-11 from GVD (regulator section) to D (regulator section)

SECTION III: SPECIFIC SWITCH POSITIONS

SWITCH POSITIONS

____ DC load ammeter to 150A.

____ DC field ammeter to 15A.

____ Field circuit switch to MANUAL.

SECTION IV: TESTING PROCEDURES

____ Main power switch ON.

____ Depress START button and hold 3 to 5 seconds.

____ Adjust vari-drive to 2000 rpm.

____ Turn master load switch ON.

____ While watching the DC voltmeter and DC load ammeter, SLOWLY turn the filed current rheostat clockwise UNTIL the DC voltmeter reads 28V.

____ Select load switches to increase present reading to 100 AMPS

____ Maintain 28 volts after applying load

____ Take a reading on the AC ammeter. While watching the AC ammeter, rotate the phase selector through A, B, and C positions. Ten amps is the maximum variation allowed between phases.

____ While watching the AC voltmeter, rotate the circuit selector through the T1-T2, T1-T3, and T2-T3 positions. One volt is the maximum, variation allowed between circuits.

SECTION V: SHUTDOWN PROCEDURES

____ Turn field current rheostat fully counterclockwise

____ Turn master load switch off

____ Turn battery switch off

____ Reduce vari-drive to 1,000 RPM.

____ Press STOP button.

____ Shut main power OFF.

____ Return all switches and controls to the base setting.

PERFORMANCE AID

300 Ampere Generator

Section I: Base Settings

Check (✓)
If Incorrect

Upper Portion of Test Stand

_____	External master power switch	Off
_____	Main power switch	Off
_____	Motor drive set for CLOCKWISE rotation of generator	
_____	DC load ammeter	500 amperes
_____	DC field ammeter	30 amperes
_____	Millivolt meter	9 volts and off
_____	DC voltmeter	50 volts and RECT/GEN
_____	Tachometer	Direct drive
_____	AC ammeter	500 amperes and phase A
_____	AC voltmeter	50 volts and off
_____	400 ampere control box	Voltage adjust full counterclockwise
_____	Equlizer coil test	Off
_____	Ignition switch	Off

Lower Portion of Test Stand

_____	Power supply switch	Off and rheostat fully counterclockwise
_____	Battery charger switch	Off and rheostat fully clockwise
_____	External field	Off
_____	Field common	Negative (-)
_____	Field circuit switch	Regulator
_____	Relay lamp	Off
_____	Regulator load resistor selector	Off
_____	Current polarity	Negative (-)
_____	Battery selector	Off
_____	Starter test switch	Off and stator voltage adjust counterclockwise
_____	All load switches	Off
_____	Field current rheostat	Fully counterclockwise
_____	Variable load	Fully counterclockwise

Bus Bars

_____ B+ to G+
_____ B- to G-

Section II: Cable Connections

_____ Test Lead No. C548-4100-16 from generator E terminal to G- terminal of test stand generator section

_____ Test Lead No. C548-4100-09 from generator B terminal to G+ terminal of test stand generator section

_____ Test Lead No. C548-4100-01 from generator A terminal to F terminal of test stand generator section

_____ Test Lead No. C548-4100-13 from generator D terminal to D terminal of test stand generator section

Section III: Specific Switch Positions

_____ Field ammeter to 15 amp position

_____ Position a 200 amp and a 100 amp load switch ON

_____ Field circuit to MANUAL

Section IV: Testing Procedure

_____ Turn main power switch ON

_____ Depress START button and hold down for 3 to 5 seconds

_____ Adjust vari-drive until 3000 RPM is obtained

_____ Turn the field current control clockwise until you read 30V on the DC voltmeter and 300A on the DC load ammeter. (You may need to use the variable 0-25 load control to obtain 300 amps.)

_____ DC field ammeter should read a maximum of 7.5A

_____ Readings other than those stated above indicate repair is necessary

Section V: Shutdown Procedures

_____ Turn field current rheostat fully counterclockwise

_____ Reduce speed to 1000 RPM

_____ Press STOP button

_____ Shut off main power

_____ Return all switches and controls to the base position

PERFORMANCE AID

60 AMP Generator

Section I: Base Settings

Upper Portion of Test Stand

________	External master power switch	Off
________	Main power switch	Off
________	Motor drive set for CLOCKWISE rotation of generator	
________	DC load ammeter	500 amperes
________	DC field ammeter	30 amperes
________	Millivolt meter	9 volts and off
________	DC voltmeter	50 volts and RECT/GEN
________	Tachometer	Direct Drive
________	AC ammeter	500 amperes and phase A
________	AC voltmeter	50 volts and off
________	400 ampere control box	Voltage adjust full counterclockwise
________	Equalizer coil test	Off
________	Ignition switch	Off

Lower Portion of Test Stand

________	Power supply switch	Off and rheostat fully counterclockwise
________	Battery charger switch	Off and rheostat fully clockwise
________	External field	Off
________	Field Common	Negative (-)
________	Field circuit switch	Regulator
________	Relay lamp	Off
________	Regulator load resistor selector	Off
________	Current polarity	Negative (-)
________	Battery selector	Off
________	Starter test switch	Off and stator voltage adjust counterclockwise
________	All load switches	Off
________	Field current rheostat	Fully counterclockwise
________	Variable load	Fully counterclockwise

Bus Bars

________ B+ to G+

________ B- to G-

Section II: Cable Connections

_______________ Test lead No C548-4100-14 from GND on electrical component to G– on test stand (Generator section)

_______________ Test lead No C548-4100-03 from B+ terminal on electrical component to G+ on test stand (Generator section)

_______________ Test lead No C548-4100-02 from Ign terminal on electrical component to F on test stand (Generator section)

_______________ Test lead No C548-4100-01 from FB regulator section test stand to Ign switch system section test stand.

Section III: Switch Positions

_______________ DC load ammeter to 150A.

_______________ DC field ammeter to 5A.

_______________ Field circuit switch to regulator.

Section IV: Testing Procedures

_______________ Main power switch on.

_______________ Depress START button and hold down 3 to 5 seconds.

_______________ Adjust vari-drive to 2000 rpm.

_______________ Calibrate tachometer.

_______________ Place battery selector in the 24V position.

_______________ Turn field current rheostat fully clockwise

_______________ Turn ignition switch on.

_______________ Read the DC load ammeter.

_______________ Turn mister load switch on.

_______________ Turn the 0-25A load rheostat clockwise until the load ammeter reads 60 amps. At this point the DC voltmeter should read 28V.

Section V: Shutdown Procedures

__________ Turn the master load switch OFF.

__________ Turn ignition switch OFF.

__________ Turn the field current rheostat fully counterclockwise.

__________ Turn battery selector to OFF.

__________ Reduce vari-drive to 1,000 RPM (direct drive).

__________ Press STOP button.

__________ Shut main power OFF.

__________ Return all switches and controls to the base setting.